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RESEARCH PAPER

A Critical Comparison of Typologies of Small-Scale Forestry in Baden-Württemberg Derived Using Single and Multiple Criteria

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Abstract The paper presents a typology of small-scale forest owners in Baden-Württemberg based on multiple criteria and derived using multivariate cluster analysis of long-term accountancy network data. Four distinct types of landholders are identified based on a combination of structural, financial and biophysical data. These groups fit well with the present knowledge on small-scale forest owners in Baden-Württemberg. In addition, the members of each group display clear differences in attitudes towards forestry, giving further support for the validity of the grouping. A comparison is made of this typology and typologies derived using the single criteria of forestry region, forest size class, cutting volume, proportion of coniferous trees, forest income and main source of income. This comparison demonstrates the advantages of using cluster analysis to identify types of small-scale forest owners in south-west Germany. No matter whether structural, natural or financial data are assessed, the multiple criteria typology produced by cluster analysis provides the highest percentage of statistically significant distinctions between the medians of the groups identified. A typology based on the single criterion of 'regions' provides the second best fit and has the advantage of being simple to develop. A more detailed comparison between these two typologies, whereby the differences between groups were analysed based on the links between

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individual groups in respect to individual variables, also indicated that the multiple criteria typology was superior.

Keywords Accountancy networks · Forest owners · Multivariate cluster analysis · Black Forest

Introduction

There is a long tradition of classifying forest enterprises into groups (or types) that share similar characteristics. For instance, Dieterich (1931) defined the type of a forest enterprise as a 'representative enterprise of a group of enterprises, which differentiate themselves by a set of characteristics from other enterprises (translation by the authors)'. Since that time, various other studies have sought to develop 'typologies' which classify forest enterprises into groups which share similar characteristics.

Emtage et al. (2006) defined a typology as an 'archetypical description of various 'typical' landholders'. A detailed overview on the various approaches that have been used to derive typologies concerning natural resource management strategies pursued by landholders is provided by Emtage et al. (2006, 2007). On the base of an extensive literature review these authors introduced a classification of typologies developed during the past 50 years using seven factors (anthropological aspects, farming scale and occupation, wealth ranking, livelihood strategies, farming systems, farming style, attitudinal aspects), which demonstrates that a wide range of characteristics has been used as the basis for developing typologies.

Emtage et al. (2006) additionally highlighted both structural and methodological aspects, and various types of variables for classifying resource user groups, which can be used to characterize forest owners. In addition, the recent overarching research of Emtage et al. (2006, 2007) suggests that nested typologies on a number of scales, repeated typology construction at regular intervals and multi-industry approaches can provide additional information about changes in rural areas including the restructuring of rural industries and changes in the values, attitudes and practices of the rural community.

Emtage et al. (2007) observed that a resurgence of typologies can be found in Europe during the last 15 years. Boon and Meilby (2007) overviewed typologies of small-scale forest owners in Europe, noting that the typologies rest mainly on quantitative survey data and can be characterized as positivistic approaches. In most cases, forest ownership objectives are used to derive the typologies. A review of European typologies by Boon et al. (2004) reveals five main owner types: (1) 'economists', (2) 'multi objective owners', (3) 'self-employed persons' (persons carry out most of the forestry work by themselves) (4) 'recreationists', and (5) 'passive/resigning owners'. Wiersum et al. (2005) undertook a cross-cultural survey in eight countries of the European Union. They defined four basic forest owner types: (1) part-time owner, (2) full-time (economically dependent) owners, (3) retired owners, and (4) owners, who live far away from their properties (absentees). Hogl et al. (2005) were able to derive a typology of Austrian forest owners, using cluster analysis in combination with factor analysis. In the latter study, a wider range of items (including

behavioural forest-related characteristics of new versus old forest owners, and socio-economic and demographic factors) was used. Hogl et al. derived seven basic types of forest owners. Further examples of regional typologies in Europe can be found in Landais (1998), Karpinnen 1998 and Mizaraite and Mizaras (2005).

It is evident from these studies that cluster analysis has become an increasingly important method for developing typologies of forest owners in Europe and elsewhere. Cluster analysis has proven to be a straightforward and convenient approach for classification of forest owners based primarily on attitudinal or behavioural aspects. However, there is no published critical assessment of the relative merits of various methodological approaches applied on the same data sets.

The present paper provides a first critical comparison of typologies of small-scale forest owners based on single criteria to a typology based on multiple criteria using cluster analysis. Typically, the variability within types in typologies based on one criteria is high (Selter 2006), and thus these approaches are limited in their applications. In this paper, a typology is developed using multiple criteria derived from data from a long-term accountancy network, and is used to assess whether this is a feasible approach to derive adequate types (with low within-type and high between-type variability) within the group of small-scale forest owners. Using the same data, a series of typologies are developed based on the 'traditional' single criterion approaches that have been used previously, and these are compared with the typology derived using multiple criteria. The typologies are then compared by identifying the number of statistically significant distinctions between types in each of the typologies, i.e. the degree to which the between-type variability is greater than the within-type variability for the various typologies.

The paper is structured as follows. The first section outlines the history and present state of typology research in Germany, and places the various approaches in the context of the stages of small-scale forestry research in Germany identified by Schraml (2004). The next section describes the methods adopted to develop typologies based on multiple criteria using cluster analysis, as well as methods to derive a series of typologies based on single criteria. Included in this section is a description of a long-term accountancy network in Baden-Württemberg which has been operating for about 30 years and from which the data are drawn to develop each typology. In addition, a survey on motivational aspects of owners of small-scale forestry enterprises is described, and the findings from this survey are used to validate the results. A critical comparison of the relative merits of multiple versus single criteria typologies is then presented. Concluding comments follow.

Forest Owner Typologies in Germany—History and Present State

There is a long history of forest owner typologies being developed and used in Germany, most of are not widely reported outside German speaking countries. As such, it is useful to outline this past research. Table 1 summarises typology research that has been undertaken in Germany and links this research to the research stages identified by Schraml (2004) and the indicators that have been used for developing typologies.

Table 1 Steps and typological approaches in small-scale forestry research in Germany in an international context

Research period[a]	Management problem addressed	Typological approach	Indicators used for typification[b]
1st 1910–1930	Technical aspects of consulting of farm forest enterprises.	Dieterich (1931): size-class, ownership class, share of forest land, organisation, operating result, objectives of forest owners.	Natural indicators: size of enterprise, number of parcels, stand volume, tree species composition
2nd 1930–appr. 1975	Mobilisation of round-timber, entrepreneurial aspects of farm forestry.	Abetz (1955): collection of physical data, some socioeconomic data; regional and size-class related types of enterprises.	Technical and entrepreneurial indicators: type of enterprise, technical equipments, manpower employed, volume of timber harvested
3rd 1975–1990	Insufficient timber mobilisation, supply behavior of forest owners.	Brandl and Löbell (1974), Steinkamp (1983): extensive monitoring of economic data; size-classes and regional classes; clusters by tree species composition, amount of timber harvested.	Social indicators: size and location of residence, income from forest, main profession of the owner, membership in forest associations, material values.
4th From 1990	Diversification, urbanisation of forest owners.	Volz and Bieling (1998), Becker and Borchers (2000), Bieling (2003), Bitter and Härdter (2003), Schraml and Volz (2003): sociological approaches, cluster analysis, motivational aspects with special regard to ecological sound forest management, groups by motivation of harvesting.	Motivational aspects: nature conservation, social status, recreation, motivation of harvesting.

[a] The research periods are drawn from Schraml (2004)

[b] The classification of indicators is based on Borgstädt (2004)

Dietrich (1931) first introduced the idea that the development of forest typologies could be an important tool in forest management. Abetz (1955) recognized the possibility of defining mentality types of small-scale forest owners and the need to be aware of these different types. Filius (1998) noted that the classification of forest enterprises in the Netherlands up to the late 1990 s was based mainly on single criteria. This also has been the case in recent years in south-west Germany. During the last decade multivariate methods have gained increasingly importance in Europe, and led to various typologies, e.g. see Karpinnen 1998, Hogl et al. 2005, Kendra and Hull 2005.

Objectives of Developing Typologies

In recent decades there has been increasing heterogeneity in the small-scale forestry sector in Germany (Schraml 2004), which has been reinforced by national

reunification and subsequent reprivatisation of forest estates and major structural changes in the closely related agricultural sector. While it is recognised that this complexity exists, it is also impossible to recognise the individual circumstances of every farmer when developing forest management and consulting tools, in the implementation of forest policy (including subsidy programs), and in designing and conducting research projects. Consequently, there is a need to reduce this complexity by grouping farmers—and their properties as business enterprises—in some manner. When developing groups however, there are a number of important considerations.

Oesten and Roeder (2002) argued that in order to be able to validly compare between business units, there is a need for sufficient similarity of the long-term physical preconditions, not influenced by short-term management objectives. Hartebrodt (2002) mentioned that for all kinds of benchmarking activities an adequate typology-based choice of the enterprises which are involved in these activities is one crucial success factor. In summary, it can be stated that one important objective of developing typologies is to provide better management and control tools for forest enterprises.

There is a high level of variability in terms of objectives and physical preconditions in forest enterprises that makes the design and implementation of forest and structural policy programs difficult (Selter 2006). For example, aggregating or classifying forest enterprises into a small numbers of groups can help political decision-makers develop subsidy schemes that meet the specific requirements of various types of forest owners. Typologies are therefore frequently used to identify recipients for State subsidies, e.g. by regional aspects, size classes or income level (Hartebrodt 2004, LFV 2004). Ziegenspeck (2002) stressed typological aspects as a relevant information source for the design of policy instruments which intend to keep the owners involved in forestry. Emtage et al. (2001) developed a typology which could be used to improve extension activities related to afforestation.

There was a continuous, albeit low-level, use of forest typologies during the research phases 1 to 3 of Table 1. The most intensive and continuous use of forest typologies in these periods was however outside the scientific arena. There was a regular application of typologies in several kinds of periodic (typically annual) reports of economic key data for the various forest ownership types, e.g. see Brandl et al. (1999) and BMELV (2006). The number of scientific research projects involving typologies increased notably in research phase 4, when more and more motivational aspects were taken into account, and increased knowledge on statistical methods widened the range of research activities.

Typologies of German Forest Owners

Borgstädt (2004) provided a detailed overview of factors which have or could be used for developing typologies of small-scale forest enterprises. The typologies developed in the research periods 1 and 2 (Table 1) are mainly based on biophysical characteristics of forest enterprises. During research period 3 there was a notable

increase in the use of characteristics related to the harvesting behaviour and financial performance as the basis of typologies. From the beginning of research period 4, there was increasing use of social characteristics and values of the owners to develop typologies.

Ownership classes are the most simple and frequently used basis for developing typologies of forest enterprises, and have been applied on all administrative levels, from the EU down to the single Federal States. There is a broad suite of applications, including policy applications, reporting schemes and the development of consulting offers for forest enterprises.

Another widely used classification is the spatial affiliation of forests, especially in southern Germany, as well as Switzerland and Austria. Forest holdings can be characterized by a wide range of landscape types, ranging from alpine to planar regions[1] (e.g. see Brandl et al. 1999; Burri 2004; Sekot 2004; Hercher and Fillbrandt 2006).

Construction of typologies based on holding size is common. Classifications by size-class are found in almost all reports containing financial performance, e.g. Brandl et al. (1999), BMELV (2006) and the annual reports of the State Forest Administration of Baden-Württemberg (LFV). Size classes have frequently been used to define recipients of specific subsidy schemes (e.g. by LFV 2004).

The amount of timber felled is also frequently used to construct typologies, especially with regard to the strong relationship between volume of timber harvested and financial operating result of the individual enterprise, examples being the typologies of Bormann et al. (2005), Hartebrodt et al. (2005), BMELV (2006) and Selter (2006). Tree species composition has a strong effect on the financial performance of forest enterprises, and several institutions use this criterion to classify forest enterprises and for a size-strata related analysis of economic results (e.g. Hartebrodt and Fillbrandt 2005, Möhring and Leefken 2005, BMELV 2006).

An increasing number of typologies based on motivational aspects have been developed in recent years. For instance, Volz und Bieling (2003) defined five basic motivational types, namely rationalist, idealist, responsible owner, traditionalist, and resigned owner. Judmann (1999) developed a classification with six types of forest-oriented owners and two types of disinterested or negative motivational forest owners. Becker and Borchers (2000) defined two typologies, each with three types. In the first typology the forest owners were classed as ‘economically interested’ (30% of owners), ‘ecologically interested’ (31%) and ‘generally interested’ owners (39%). The second typology was derived for the owners of very small holdings. Here they found ‘recreationists’ (37%), ‘economic interested’ (13%) and ‘pragmatics’ who are interested in both economic and recreational aspects (50%). Bieling (2003) classified small-scale forest owners into three categories, namely ‘economic interested’, ‘idealistic interested’ and ‘disinterested owners’.

[1] The range between alpine and planar regions reflects various factors, including precipitation level, temperature, tree species compositions, soil conditions, and also economic factors such as infrastructure and restrictions due to recreation and tourism.

Research Method

A multi-criteria typology of landholders was developed using cluster analysis based on data collected from the long-term accountancy network of forest owners maintained by the Baden-Württemberg Forest Research Institute since 1979 and stored in a relational database. Six further typologies were developed based on single variables from the same data set. The seven typologies were then compared.

Sources of Data

Annual questionnaires completed by members of the network for small-scale forestry enterprises provide a set of socio-economic observations since 1979 (Brandl et al. 1999). This monitoring-system is conducted for the federal state of Baden-Württemberg in the south-west Germany. These forest owners generally derive most of income from forestry or agricultural activities, sometimes supplemented by income from farm tourism and non-farm activities (Selter 2003). In addition, there are some 'urban' forest owners, who have given up the agricultural activities of the farm and earn most of their income from non-farm sources. The participation in the accountancy network is voluntary and data are collected by personal interviews each year. The set of farms involved in the accountancy network is highly stable, with over 100 of the current 160 being members since the inception of the network nearly 30 years ago. This constancy of membership offers many interesting opportunities for analysis. In condensed form, data on 58 variables are published yearly (Baron et al. 2004).

The Cluster Analysis Procedure

For the cluster analysis, observations of 70 variables for 160 farm forestry enterprises were extracted from the relational database maintained for the accountancy network for forest areas of between 5 and 200 ha. The choice of variables was based on an assessment of their potential for distinguishing between farms. A 5-year average (for 1998–2002) for each variable was calculated in order to reduce the between-year variability which is an intrinsic part of forestry operations and is exacerbated by unusual events, notably storms. In many cases the variables were aggregates of other variables. For instance, seven age classes of spruce were combined to produce an aggregate variable for total percentage of spruce on the farm. Similarly, financial variables were aggregated into main cost and revenue categories.

Spearman rank correlation coefficients were calculated for each pair of continuous variables (following Backhaus et al. 2000), the list of continuous variables being reduced to 13. Eliminating variables with high correlations reduced the potential for the disproportionate impacts that variables exhibiting multi-colinearity can have on hierarchical cluster analysis (Hair et al. 1998). An additional three binary variables dealing with sources of income were also included in the cluster analysis. The variables extracted fell into three main categories—structural, natural and economic (i.e. operational and financial aspects) (Table 2). The raw data

Table 2 Variables used in the cluster analysis

Category of information	Variable
Structural data referring to the farm	
Agricultural part	Agricultural area (ha)
	Land expectation value for agricultural activities (€/ha)
Forestry part	Forest area (ha)
	Land expectation value for forestry activities (€/ha)
Whole farm	Source of income (divided in three binary variables
Natural data (forestry part only)	Growing stock volume – total (m^3/ha)
	Growing stock volume (even-aged deciduous trees) (m^3/ha)
	Associated species (silver fir, Douglas fir, deciduous trees) to an age of 40 years (%)
Economic data (forest part only)	Family working hours spent on timber harvesting (hours/ha)
	Income for other non-timber forest products (€/ha)
	Subsidies received for silviculture (€/ha)
	Total expenditure on paid labour and contractors (€/ha)
	Fixed expenditure (€/ha)
	Family income (excludes family labour costs) (€/ha)

for the variables were transformed into z scores before being used as input into a hierarchical cluster analysis using Ward's Method and Squared Euclidian Distance. SPSS Version 11.0 was used for the analysis.

Validation of Landholder Groups

Groups identified by cluster analysis were validated in two ways. First, group (cluster) means were calculated for the 58 variables extracted from the accountancy network database and published yearly in external reports. These means were then compared using statistical tests. For the groups to have high validity, it would be expected that there would be much greater variation between group means than within groups.

Second, data related to motivational aspects of the owners were extracted from an independent study and group means for these variables were calculated and compared. During a survey in spring 2005, the leaders of farm forest enterprises involved in the accountancy network were interviewed about motivational aspects that determine or influence the way in which they manage their forests. The interviews were conducted by members of the research team responsible for the accountancy network (including one of the authors). The questionnaire used in the interviews was developed by Borgstädt (2004) and based on the studies of Ziegenspeck (2002) and Bieling (2003). The data on forest owner motivations were collected independent of the data used in the cluster analysis. These data were recorded in a manner which allowed individual landholders and hence the groups to which they belonged to be identified. This allowed group means for the various motivational variables to be calculated. The data collected from the interviews were

analysed using cross tabulations and principal component analysis, including 12 variables describing motivational aspects. Forest owner types were identified using cluster analysis, on the basis of data related to the structural, economic and natural characteristics of the farms. It is reasonable to assume that members of each group also might have different motivational characteristics such as their attitudes towards land use, nature conservation or expected income. Hence it was judged that the data from the 'motivations' survey have potential to validate the groups identified from the cluster analysis. For each group, a motivational profile was developed and significant differences were identified between group means.

Development of Alternative Typologies

Six further typologies were developed based on single variables extracted from the accountancy network records, namely region, forest size, cutting volume, percentage of coniferous trees, forest income and main source of income. The types within each typology are set out in Table 3.

Statistical Analysis of Differences Between Types Within Typologies

Data observations for most variables were not normally distributed, hence non-parametric statistical tests were used to identify significant differences between forest owner types within a particular typology. The Kruskal-Wallis H-test was used to identify significant differences between types. Where significant differences were

Table 3 Details of typologies developed using cluster analysis and single variables

Typology name	Basis of typology	Forest owner types identified
Cluster	Multiple criteria using cluster analysis (4 groups)	Forest professionals, conventional farmers, land users with mainly idealistic interests, land users in favoured sites with above-average intensity in land use
Region	Regional parts of Baden-Wuerttemberg (4 groups)	Black Forest (western and south-western parts of Baden-Wuerttemberg), eastern and south-eastern parts, north-eastern parts, northern parts of Baden-Wuerttemberg.
Size class	Size of the forest area in hectare (4 groups)	5–9.9 ha, 10–19.9 ha, 20-49.9 ha, 50-200 ha
Cutting volume	Volume of timber-cutting in m^3/ha (4 groups)	<3.5 m^3/ha, 3.5–5.4 m^3/ha, 5.5–7.4 m^3/ha, >7.4 m^3/ha
Percentage of coniferous trees	Percentage of coniferous trees (3 groups)	<45%, 45–73%, >73%
Forest income	Percentage of forest income in whole family income (3 groups)	<5%, 5–25%, >25%
Main source of income	Main source of income regarding to the whole family income (4 groups)	Main income forestry, main income agriculture, main income from other sources, forest owners without agricultural land use

identified, the Mann–Whitney U-test was used to identify significant differences between pairs of types. Accordingly, if there are four types within a typology, with each type compared with each other type (1:2, 1:3, 1:4, 2:3, 2:4, 3:4), there are six links between the types as well as six individual U-tests. The differences, for categorical and ordinal variables, were tested with the χ^2 test.

Results

Comparison of Forest Owner Groups Based on Multiple Criteria

Four groups (clusters) of small-scale forest owners were identified from the cluster analysis of the accountancy network data. Table 4 summarizes the most important differences between these groups. The groups were assigned names to facilitate a better understanding when explained in the text. This naming system should not be interpreted as an attempt to break down the multi-layered picture of the mixed farms into one adjective or as a return to stratification based on single criteria.

Forest Professionals

This type possesses the largest forest areas and medium-sized agricultural areas. Most of their income is derived from using their land. Their farms consist mainly of sites suited to forestry but not cropping (i.e. a high land expectation value for

Table 4 Significant characteristics of the four groups, based on the Mann–Whitney and chi-squared tests

Characteristics	Forest professionals	Conventional farmers	Idealists	High intensity farmers
Number of forest owners	23	73	31	21
Forest area	+	0	−	0
Agricultural area	0	+	−	0
Land expectation value forestry	+	−	−	+
Land expectation value agriculture	−	0	−	+
Main income land use	85%	100%	0%	81%
Percentage of Norway spruce	−	0	−	+
Timber damages	+	0	0	+
Standing timber volume	0	0	0	+
Environmentally sound forest management	+	−	0	−
Prices for timber selling	+	−	−	+
Help of contractors	+	−	0	0
Working productivity timber harvesting	+	−	−	0
Family income forestry per hectare	0	0	−	+
Family income forestry per farm	+	0^-	−	0^+
Net revenue (€/ha)	+	0	−	+

'−' = below average, '0' = average, '+' = above-average

forestry and a low agricultural land expectation value). The forest professionals practice environmentally sound forest management by increasing the percentage of deciduous trees and silver fir in their forests. Landholders in this type receive on average the second highest average selling price for timber (in €/m^3) and the highest aggregate total proceeds. The members of this group are working efficiently with comparatively modern and efficient technical equipment. When severe forest damage occurs (e.g. storm damage), they employ contractors to make up shortfalls in their harvesting capacity. Members of this group have the highest family income per farm and medium-sized family income per hectare. If the value of family labour is excluded, the forest professionals achieve above-average net revenue per hectare.

Conventional Farmers

These farmers possess medium-sized forest areas and large agricultural areas. Their main income is derived by using land. In contrast to the forest professionals, the land they own or lease has a high land expectation value for agricultural activities. They implement measures of environmentally sound forest management only on a low level. The conventional farmers receive relatively low proceeds for timber-selling. They have the lowest costs for contractors and self-employment is of high importance to use their own machines and labour to capacity. Members of this group generally own equipment suited to their agricultural activities; their operations have moderate fixed costs and they achieve medium-sized financial returns.

Idealists

Forest owners with mainly idealistic interests typically possess small forest areas and only small or no agricultural areas. In contrast to the other groups, their main income is not from the land they own. Their land has low agricultural and forestry productivity. They implement measures of environmentally sound forest management at a medium level. Members from this group typically receive low proceeds from timber sales and they expend many working hours per hectare of stocked area and per cubic metre of timber harvested. They occasionally employ contractors. In comparison to the others, this group achieves low financial results.

High-Intensity Farmers

These landowners are in favoured sites with above-average land-use intensity and possess small forest areas and medium-sized agricultural areas. Their main income is derived by land use. They are using sites with the highest land expectation values for forestry and for agriculture. Their natural resources are characterized by a high volume of standing timber, a high percentage of spruce and a high volume of timber damaged by storm, snow or insects. Seldom if ever do they implement environmentally sound forest management. They generate the highest proceeds for timber-selling (in €/m^3) and manage their forests mostly with family labour. The intensive land users receive the highest family income and net revenue per hectare.

Reflection of Groups by Means of a Comparison with Motivational Aspects

Three dimensions of 'motivations' for landholders to manage their land were identified from exploratory data analysis and factor analysis of data collected from landholder interviews. These dimensions were labelled 'income', 'family working' and 'nature'. The dimension 'income' includes the assessment of the forest owner about his forest as a source of income, his interest in the production of high-value timber, and the priority he places on independence in work tasks and on wildlife management. The dimension 'family working' is characterized by the owner's capacity of family working hours and his valuation of forest work as a possibility to compensate seasonal variation of workload. The dimension 'nature' consists of the owner's motivation for nature conservation by forest management, his valuation of biodiversity in forests and his valuation of recreational aspects of his own forest. The average values for each landholder type are presented in Table 5.

In contrast to the forest professionals, the aspects referring to the dimension 'income' are less important for the land users with idealistic interests. However, both groups assessed the dimension 'nature' as important. This agrees with the finding of Bieling (2003), of an increased willingness to implement practices of environmentally-sound forest management for both, owners with great economic interest and owners with great idealistical interest in their forest.

The significant differences between groups, which are illustrated in Table 4, support the contention that cluster analysis is an adequate procedure to derive classifications for accountancy networks.

Comparison with Traditional Forest Owner Typologies

The multi-criteria typology developed using cluster analysis was compared to single criteria typologies outlined in Table 3. This set of traditional single-criteria typologies is based on the typologies adopted in the annual reports prepared by the Baden Württemberg Forest Research Institute (e.g. by Baron et al. 2004) about forest accountancy networks in Baden-Wuerttemberg and Germany. The set also conforms with proposals of Oesten and Roeder (2002) in guidelines for typologies. The 58 variables commonly reported from the accountancy network were used as the basis of comparison. Table 6 reports numbers of statistically significant differences, which provide a comparison of the power of each typology to explain patterns and similarities of entrepreneurial behaviour and forest management strategies between types of forest owners.

Table 5 Characteristics of the four groups in relation to the importance of the dimensions income, family working and nature to the forest owners (Kruskal-Wallis test, $P < 0.05$)

Dimension	Forest professionals	Conventional farmers	Idealists	High intensity farmers
Income	+	0	−	0^{+}
Family working	0	+	−	0
Nature	+	0	+	0

'−' = below average, '0' = average, '+' = above-average

Table 6 Number and percentage of variables for which values differ significantly from one other variable (global significance according to Kruskal-Wallis and chi-squared tests)[a]

Variable group		Typology based on						
		Cluster	Regions	Size-classes	Cutting volume	Percentage of coniferous trees	Forest income	Main source of income
Structural data referred to the farm	Number	10	8	10	4	2	6	9
	Percentage (%)	83	67	83	33	17	50	82
Natural data	Number	11	11	5	5	8	7	4
	Percentage (%)	92	92	42	42	67	58	33
Financial/ operative data	Number	29	21	15	26	10	17	9
	Percentage (%)	83	60	43	74	29	49	26
All variables	Number	50	40	30	35	20	30	22
	Percentage (%)	85	68	51	59	34	51	38

[a] Natural or biophysical data refer to tree species, and distributions of height and volume of trees

From Table 6 it is clear that the cluster analysis produces the best characterization of groups across the entire set of 58 variables reported annually. Similarly, for each of the groups of variables (i.e. structural, natural, and financial or operative variables) the typology produced by cluster analysis produces the greatest number of significant differences between the types within the typology. For each group of variables, there are a number of other typologies that also produce high numbers of significant differences; however, the typology based on multiple criteria is consistently the best across all variable groups, with the typology based on regions being the second best. These two typologies thus warrant further analysis.

Both typologies consist of four groups, and within each typology there are 348 links possible between each of the groups.[2] Figure 1 presents the number of significant links ($P < 0.05$). The results of the U-tests to identify significant differences for each variable between each of the groups are presented in Fig. 1. There were many more significant differences between the four types in the typology derived by cluster analysis compared with the four types in the regions-based typology, with 51% compared to 41% of the variables respectively showing statistically significant differences (Table 7).

Table 7 also provides a breakdown of significant differences between each of the main categories of variables. The cluster analysis typology has a greater number of significant differences in variables compared to the regions-based typology. If simply restricted to natural resources, the typology which applies regional stratifications explains more differences between groups, regarding the site. However, characteristics of natural variables, which are dependent of the

[2] A comparison of four types, each with each, requires six comparisons. These six comparisons have to be made for each of the 58 variables, hence there are 58 x 6 or 348 combinations.

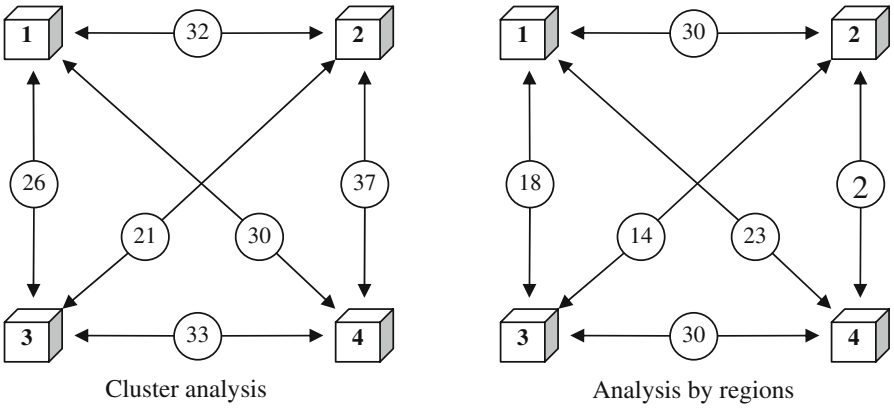

Fig. 1 Number of statistically significant differences ($P < 0.05$) of variables between the sub-groups of the typologies according to cluster analysis and regions (Mann–Whitney test) Note: For cluster analysis, 1 = forest professionals, 2 = conventional farmers, 3 = land users with mainly idealistic interests, 4 = land users in favoured sites with above-average intensity in land use. For 'regions', 1 = Black Forest (western and south-western parts of Baden-Wuerttemberg), 2 = eastern and south-eastern parts, 3 = north-eastern parts, 4 = northern parts of Baden-Wuerttemberg

Table 7 Proportion of statistically significant differences on the basis of all possible links ($P < 0.05$)[a]

Variables	Number of possible links	Percentage of links with significant differences according to typology	
		Cluster (%)	Regions (%)
All variables	348	51	41
Category of variable			
Structural data	72	63	35
Natural data	72	47	57
Financial/operative data	204	49	37

[a] Significance according to the Mann–Whitney test

entrepreneurial behaviour of the leader of the farm—such as percentage of associated ecologically valuable tree species (e.g. deciduous trees or silver fir) younger than 40 years, or cutting volume—are better represented by multivariate classification.

Discussion

Cluster analysis has been found more useful as a basis of developing a typology of forest owners than defining typologies based on single variables such as regions or forestry land size classes. The analysis establishes groups of forest enterprises that have similarities in essential social, structural and economic characteristics, so as to be distinguishable from other groups. By applying cluster analysis to the multiple criteria from accountancy networks, this study has identified the groups of 'forest

professionals', 'conventional farmers', 'idealists' and 'intensive farmers'. The comparison of this typology with various single criterion typologies confirms the hypothesis that the application of multivariate statistical methods (i.e. allowing the use of multiple criteria) depicts farm-forest management much better with respect to the diversity of the attitudes and behaviour of the owners and the changing general conditions than single criteria classifications.

The comparison between traditionally used typologies and cluster analysis demonstrates the advantage of a clearer differentiation of types of forest owners. The results of the analysis especially make clear that the entrepreneurial behaviour of the farmer and his family is dependent on a complex set of factors. These relations are better characterized by multiple criteria than single variable classifications.

The traditional stratifications of small-scale forestry enterprises were often part of research interests at the time, or were driven by temporary political interest (e.g. roundwood mobilisation) (Schraml 2004 and Table 1). However, these methods yield adequate results only to sectoral questions (e.g. they provide a classification by the volume harvested as a satisfactory explanation for the basic economic results) and both scientists and politicians accepted a large variance within the groups.

The typology based on cluster analysis has the best performance (as measured by the highest proportion of significant differences in key variables) across each of three categories of variables (i.e. structural, natural and financial) (Table 6). If the data availability are not appropriate to apply multivariate methods, then stratification according to regions is the second best option in situations where a broad-based classification scheme is needed. Membership of a region implicitly incorporates many of physical variables because these typically differ between regions. In a sense, the region-based classification incorporates multiple criteria, given that relevant key drivers for forest management (e.g. tree species composition, climate, forest history) are bound to the region. It can be argued that in effect a region-based classification is a surrogate for a multivariate approach and could be an adequate approach when classifications are needed to represent structural, natural and financial aspects. This is not to suggest that classifications using multiple variables are always needed. For instance, if the focus lies on financial questions, classification according to the cutting volume would be appropriate. If the focus lies on issues associated with socio-economic aspects of the whole farm (e.g. income structure, family working hours, professional education) then a classification according to farm size or main income source is appropriate.

Emtage et al. (2006) discussed the relationship between the results of clustering and the indicator set used for clustering, and concluded that high data quality and availability is an important precondition for successful clustering. Consequently, it has been demonstrated in the current paper that the use of a broad set of data out of a long-term accountancy network provides relevant benefits, with special regard to these two major problems associated with developing typologies. First, data can be made available, due to the fact that accountancy networks contain in general a broad set of variables, as was the case with the network used in the current study. Second, using data from accountancy networks can often help reduce the number of outliers because of the opportunity to use time series data instead of single observations. In

the case of the present study, averages based on data over a five year period were used. Especially in the forest sector, where natural disasters can be dominant in some years, this is an effective approach to reducing inter-year variability in the analysis. Accountancy-network-based typologies can also be of particular usefulness when processes of change and restructuring have to be observed.

Concluding Comments

It will not always be possible to develop forest owner typologies using cluster analysis, because this can be time-consuming and challenging. A more extensive knowledge on the risks and opportunities of various single criteria approaches can help to improve the quality of research findings, management and reporting tools, wherever such a multiple criteria approach is not feasible. This study indicates for example that within the group of small-scale forest owners, the single criteria of spatial location of forest enterprises (i.e. grouping by regions) is the second best basis of constructing typologies in Baden-Württemberg. Single-criteria typologies (e.g. size of enterprise, tree species composition, volume harvested) can be useful, although care needs to be taken to define them according to a variable that corresponds to the specific purpose or objective for which they are being developed.

With regard to government policies, the findings provide evidence that, in comparison with national or EU-wide approaches, regional approaches might be a more feasible way to deal with the complexity of forest enterprises. Specialised programs in various regions can improve the effectiveness of these government policies, but unfortunately there are trends at the EU and federal level, to find more generalizing approaches in forest and agricultural policy.

The application of cluster analysis, resting upon multiple criteria coming from accountancy networks of private and communal forest enterprises with more than 200 ha of forest estate for calculation of weighted means, notably improved the comparability with results of a nationwide forest inventory, with special regard to relevant silvicutural data, for example. While the current study has provided evidence about the transferability of alternative methods of developing typologies to other owner collectives, there remains the necessity to verify these results. A special point of interest is whether one can find an equal ranking of different methods of developing typologies in the different areas in all ownership groups. If yes, this would suggest the possibility of defining general rules for developing typologies, and thereby enhance the possibility to reduce the high research effort for multiple criteria analysis.

At present additional multivariate analysis is being carried out for private and communal forest estates and this analysis will provide further insights into the broader applicability of typologies of forest enterprises derived using clustering techniques. Irrespective of the results obtained, what will remain definitely is the fact that within the group of small-scale forest enterprises hard-fact based multivariate cluster analysis is at present the undisputed benchmark for all other approaches to developing typologies.

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